Catalogue no. 85-561-M — No. 015
ISSN: 1707-5203
ISBN: 978-1-100-10842-1

Research Paper

Crime and Justice Research Paper Series

Analysis of the Spatial Distribution of Crime in Canada: Summary of Major Trends 1999, 2001, 2003 and 2006

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Canadian Centre for Justice Statistics, Statistics Canada

Published by authority of the Minister responsible for Statistics Canada

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October 2008

Catalogue no. 85-561-M No. 015

Frequency: Occasional

ISSN 1707-5203

ISBN 978-1-100-10842-1

Ottawa

Cette publication est disponible en français (nº 85-561-M nº 015 au catalogue)

Statistics Canada

Acknowledgements

The Canadian Centre for Justice Statistics (CCJS) produced this research paper with the financial assistance of the National Crime Prevention Centre (NCPC) at Public Safety Canada. The NCPC has been a key partner in the development of spatial analyses of crime since 2003. The CCJS also wishes to thank the participating police forces and urban planning services for their interest in these projects.

These analyses are the result of close collaboration among a number of divisions of Statistics Canada. The author would like to acknowledge the outstanding analytical work of the many individuals who contributed to this series: Cory Aston, Frédéric Bédard, Mathieu Charron, Krista Collins, Robin Fitzgerald, Samuel Perreault, Marnie Wallace and Michael Wisener.

The various phases of the publication process for this paper were carried out with the assistance of Danielle Baum, Denyse Carrière, Judith Côté, Colleen Thompson and Suzane Tremblay. The author wishes to express her sincere appreciation for the support provided by this team throughout this analytical series.

Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

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Introduction

This paper summarizes the major trends in the series on the spatial analysis of crime conducted by the Canadian Centre for Justice Statistics (CCJS) using geographic information system technology in Canadian cities. The main purpose of this analytical series, which was funded by the National Crime Prevention Centre at Public Safety Canada, was to explore the relationships between the distribution of crime and the demographic, socio-economic and functional characteristics of neighbourhoods.

In particular, the following questions were addressed in these crime diagnostic studies: How are police-reported criminal incidents distributed across city neighbourhoods? Is the crime rate in a neighbourhood associated with factors that are specific to that neighbourhood, such as its demographic, socio-economic, housing and land use characteristics? Is the crime rate in a neighbourhood influenced by nearby neighbourhoods? These questions were explored using data from the 2001 Census of Population, the Incident-Based Uniform Crime Reporting Survey (UCR2), and land use data provided by the various cities.

In recent years, there has been growing interest in the socio-economic performance of various Canadian communities (Heisz 2005; Alasia et al. 2008). Today, it is generally acknowledged that communities have different characteristics that determine their social development potential. This paper summarizes the major crime patterns in several Canadian cities based on socio-economic, dwelling and city-zoning characteristics. These diagnostic studies were conducted in seven cities: Edmonton, Halifax, Regina, Montréal, Saskatoon, Thunder Bay and Winnipeg. Evidence was obtained with a view to developing crime prevention policies and strategies. Consequently, these research results will be useful in targeting efforts, demonstrating the diversity of crime prevention approaches available, and fostering the creation of partnerships among key stakeholders.

The first section of this paper explores the trends in the spatial distribution of crime in the seven participating cities. The main similarities and differences in the spatial distribution of crime in Canadian cities are identified. The second section looks at the major risk factors, or the demographic, socio-economic and functional characteristics associated with differences in crime rates among neighbourhoods in the various cities. The results of the thematic issues addressed in the analytical series are presented in the third section. These issues relate to spatial variations in crime by time of day; distances travelled by persons charged; youth crime rates; the relationship between crime rates and the Aboriginal population; and variations in crime and neighbourhood characteristics over time. The fourth section of this paper presents the main conclusions and potential for analysing crime in the Canadian context in the future, while the last section briefly sets out the data sources and some of the methodology used in our analyses in this series.

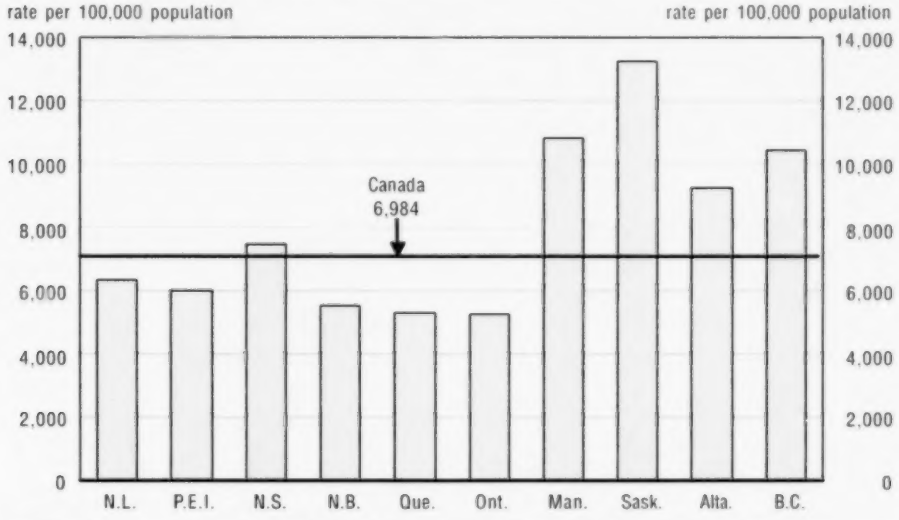
Findings

Spatial distribution of crime

Crime is not randomly distributed across Canada

Traditionally, crime data in Canada have been analysed and released at the national, provincial and census metropolitan area (CMA) levels. Crime rates typically vary from east to west in the country, with the Eastern provinces recording the lowest crime rates, and the Western provinces, the highest rates (Chart 1).

Chart 1
Crime rate by province, 2007



Source: Statistics Canada, Canadian Centre for Justice Statistics, Uniform Crime Reporting Survey.

A comparative study (Francisco and Chénier 2007) of crime rates in CMAs, small urban centres and rural areas revealed that crime was not necessarily a large urban phenomenon. More specifically, small urban centres reported overall crime rates that were higher than those of major urban centres, while the lowest crime rates were found in rural areas. These findings were consistent in all provinces and territories, except Quebec and Alberta. In Quebec, the highest overall crime rates occurred in the major urban centres, while in Alberta, the major urban centres had the lowest crime rates.

However, even within CMAs, crime rates are not uniformly distributed. The cities of Winnipeg, Montréal, Regina, Edmonton, Halifax, Saskatoon and Thunder Bay represent both the core of the CMAs of the same names and the economic centres of these CMAs. The police forces in these cities report higher crime rates than in all other municipalities that make up the CMAs.

These findings show that crime is not uniformly distributed across Canada, with some regions having substantially higher crime rates. With the recent introduction of geocoding of crime data, it is now possible to analyse the spatial distribution of crime at a lower level and to identify the risk and protection factors associated with crime in various Canadian cities.

Crime is concentrated in a limited number of neighbourhoods

The mapping of crime in Canadian cities indicates that crime is concentrated in a limited number of neighbourhoods, notably in the core neighbourhoods of these cities. A small number of incidents were reported by police in the peripheral areas of the cities.

In all of the Canadian cities examined, the highest rates of property crime were concentrated in the city centres. Hot spots of lesser intensity were also found near shopping centres and superstores or power centres.

Violent crime rates were also highest in the core neighbourhoods of the cities studied. Edmonton, Halifax and Montréal also had several areas of moderate crime intensity in residential neighbourhoods.

The Winnipeg and Thunder Bay studies illustrated to a greater degree this trend of crime being concentrated in core neighbourhoods. First, the Winnipeg study showed a concentric distribution of crime and gradual lessening of the density of criminal incidents with increasing distance from the city center. The Thunder Bay study also showed this decline in the concentration of crime based on distance from one of the two city centres that make up the city.

To better understand the spatial distribution of crime in Canadian cities, various studies have tried to take into account the spatial distribution of populations at risk, that is, those populations that may be the target of crime. Thus, when the relative distribution of the population living or working in a city was taken into consideration along with the relative concentration of criminal incidents in that city, the crime hot spots in Canadian cities changed. In all Canadian cities, the area and intensity of hot spots for property crimes in core neighbourhoods diminished with increasing density of the population at risk, while several other small concentrations located close to shopping malls and superstores increased.

General trends or violent crime distribution patterns were more varied based on the at-risk population. An initial pattern based on the population residing or working in the neighbourhoods indicated that crime was distributed across several hot spots not exclusive to neighbourhoods in city centres but also in certain residential neighbourhoods. In particular, this was the case in Montréal, Edmonton and Thunder Bay. The cities of Regina and Winnipeg showed a second pattern, in which concentrations increased and were almost exclusive to the city centre. A third pattern of crime distribution by population at risk was illustrated by the Halifax study, where concentrations remained in the same neighbourhoods, but declined in intensity and area.

Risk factors

The spatial organization of crime in Canadian cities is linked to a set of demographic, socio-economic and functional factors

Numerous studies have documented the relationship between neighbourhood characteristics and crime rates. However, these studies have differed with respect to the importance they placed on factors such as low income, residential mobility, ethnocultural composition, opportunities for criminal behaviour, collective efficacy (or the level of trust and reciprocity in a neighbourhood), and social disorganization (or a decrease in the influence of social rules over behaviour) (Shaw and McKay 1942; Cohen and Felson 1979; Brantingham and Brantingham 1982; Ronek and Maier 1991; Sampson and Lauritsen 1994; Sampson et al. 1997).

In the spatial analysis series, the relationship between many factors and the rates of violent and property crime in the various neighbourhoods of the Canadian cities included in the studies was also explored. Several differences in the characteristics of high-crime neighbourhoods (those with rates in the upper quartile) and low-crime neighbourhoods (those with rates in the lower three quartiles) were noted in all of the cities examined (Table 1). These differences can be grouped under three main dimensions: demographic, socio-economic and functional.

The results of these studies must not be taken to mean that some neighbourhood characteristics are the cause of crime. Rather, the results indicate that these factors are linked to or coincide with higher neighbourhood crime rates. These are crime rates that are measured at the neighbourhood level, not the delinquency rates of the residents in these neighbourhoods.

Demographic dimension

In the cities examined, the demographic characteristics of high-crime neighbourhoods differed from those of lower-crime neighbourhoods. These characteristics are inextricably linked to the demographic composition of cities in the country's different regions.

All of the high-crime neighbourhoods had higher proportions of single people, people living alone, lone-parent families, and people who had moved in the year preceding the Census. The male-female ratio, and higher proportions of the population aged 15 years or younger and of young men aged 15 to 24 were not necessarily associated with high-crime neighbourhoods.

The analyses presented here did not find causal links between residents and the level of crime in their neighbourhood. However, many studies have found links between these demographic characteristics and higher rates of victimization and delinquency (Kong 2005). These characteristics might also play a role in the ability of neighbourhood residents to exercise informal social control (Shaw and McKay 1942).

Table 1

Differences between high- and low-crime neighbourhoods, selected cities, 2001

	Edmonton		Halifax		Montréal		Regina		Thunder Bay		Winnipeg		Saskatoon	
	Violent	Property	Violent	Property	Violent	Property	Violent	Property	Violent	Property	Violent	Property	Violent	Property
Demographic characteristics														
Male-female ratio	√	√	√	–	–	–	–	–	–	–	√	√	√	√
Proportion of people younger than 25	–	√	...	...	–	–	...	...	–	–	–	–	√	–
Proportion of young men aged 15 to 24	√	√	–	–	√	√	.	.	–	–	–	–	–	–
Proportion of single people	√	√	√	–	√	√	√	√	√	√	.	.	√	√
Proportion of lone-parent families	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Proportion of people living alone	√	√	√	√	√	√	–	–	√	√	√	√	√	√
Proportion of people having moved in the previous year	√	√	√	–	√	√	√	√	√	√	√	√	√	√
Proportion of Aboriginal people	√	√	√	–	...	...	√	√	√	√	√	√	√	√
Proportion of visible minorities	–	–	–	–	–	–	–	–	–	–	√	√	–	–
Proportion of immigrants	–	–	–	–	√	√	–	–	...	...	√	√	–	–
Socio-economic characteristics														
Unemployment rate	√	√	√	–	√	√	√	√	–	–	√	√	√	√
Proportion of the population aged 20 years and older without a high school diploma	√	√	–	–	√	√	√	√	√	√	√	√	√	√
Proportion of the population aged 20 years and older with a university diploma	√	√	–	–	√	–	√	√	√	√	√	√	√	√
Occupation	√	√	√	–	√	–	√	√	√	√	√	√	.	.
Median household income	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Proportion of total income represented by government transfers	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Proportion of population in low-income households	√	√	√	–	√	√	√	√	√	√	√	√	√	√
Proportion of households spending more than 30% on shelter	√	√	√	√	√	√	√	√	√	√	√	√	.	.
Dwelling and land use characteristics														
Bar density	.	.	.	.	–	√	.	.	.	.	.	.	.	.
Proportion of dwellings in need of major repairs	√	√	√	–	√	√	√	√	√	√	√	√	√	√
Proportion of dwellings built before 1961	√	√	–	–	√	√	√	√	–	√	√	√	√	√
Proportion of owner-occupied dwellings	√	√	√	–	√	√	√	√	√	√	√	√	√	√
Multiple-family residential zoning[1]	√	√	√	–	√	√	√	√	–	√	–	–	√	√
Commercial zoning[2]	√	√	√	√	–	–	.	.	√	√	√	√	√	√
Single-family residential zoning[3]	√	√	√	√	√	√	√	√	√	√	√	√	√	√

. not available for any reference period

... not applicable (This characteristic represents a proportion of the city's population that is too low).

√ The figure for high-crime neighbourhoods was statistically different from the figure for low-crime neighbourhoods ($p < 0.05$).

– Difference is not statistically significant.

1. For Edmonton and Saskatoon, this characteristic is measured using the percentage of apartment buildings.
2. For Edmonton and Saskatoon, this characteristic is measured using the number of people working in retail trade.
3. For Edmonton and Saskatoon, this characteristic is measured using the percentage of detached single-family dwellings.

Notes: For most of the cities examined, the significance of the relationship was established by comparing the values for high-crime neighbourhoods (upper quartile) with those of lower-crime neighbourhoods (three other quartiles). For Thunder Bay, the significance between the four quartiles was tested. In Saskatoon, this represented the significance of the correlation coefficient (Pearson) for all of the neighbourhoods (results not previously released).

Sources: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001 and Census 2001.

Socio-economic dimension

A number of American studies have also shown that inequality of socio-economic resources among city neighbourhoods is strongly correlated with the spatial distribution of crime (Morenoff, Sampson and Raudenbush 2001). Results suggest that in all of the Canadian cities examined, crime is concentrated in neighbourhoods where residents have limited access to socio-economic resources.

High-crime neighbourhoods typically have a population that is more disadvantaged in economic terms (higher proportions of government transfers and of people living in low-income households, and lower median incomes) and a smaller proportion of highly educated people. In addition, in high-crime neighbourhoods, a larger proportion of the population spends more than 30% of its income on shelter and a smaller number of dwellings are owner-occupied.

The overlapping of these different socio-economic characteristics in cities was abundantly clear from the New Approaches for Addressing Poverty and Exclusion project conducted by the Government of Canada's Policy Research Initiative (Hatfield 2004). The Research Initiative's conclusions showed that the phenomena of social exclusion and persistent low income are closely related (Kunz and Frank 2004). Many of the factors associated with persistent low income reflect the absence, ineffectiveness or disruption of social networks, or more particularly, the social ties that provide access to income from stable paid employment (Hatfield 2004). People belonging to at-risk groups (members of lone-parent families, elderly people living alone, people with a work-limiting disability, Aboriginal people living off reserves and new immigrants) share a number of problems, but each stands out by a specific event, whether it be a change in family status or even the lack of such status, a health problem or a move (Hatfield 2004).

In this context, high neighbourhood crime rates appear to reflect the absence, disruption or ineffectiveness of social networks (social capital) that enable people to participate in the community and exert social control. Crime would appear to be a symptom of social exclusion, which in turn could prevent neighbourhood residents from exerting social control.

Functional dimension (land use and dwelling characteristics)

The functional characteristics of neighbourhoods contribute to the differences in crime rates among neighbourhoods. In fact, high-crime neighbourhoods are the busiest neighbourhoods, whether they are located near city centres or they support high levels of commercial activity.

While city centres are the major hot spots in Canadian cities in absolute numbers, some other areas have higher crime rates. Most of these hot spots are areas of higher commercial activity (shopping malls and superstores) and are the focus of a relatively large number of property crimes (most of which are thefts under $5,000) but also, to a lesser extent, of violent crimes. West Edmonton Mall is an especially obvious example of this type of hot spot, as is the Montreal Pierre Elliot Trudeau International Airport.

Residential neighbourhoods are moderate crime areas. Various types of crimes are recorded there, including breaking and entering and assault. However,

except for a few multiple-family residential areas, they do not exhibit any particular spatial concentration.

In all the cities examined, there was also a correlation between the housing conditions and crime. In high-crime neighbourhoods, a higher proportion of housing needed major repairs.

Other hot spots were institutions: schools, universities, hospitals, etc. However, since neither students nor patients were taken into account in calculating the at-risk population for our analyses, the at-risk population in these places may have been underestimated, thereby creating more intense hot spots. The relatively higher concentrations around the Lakehead University campus in Thunder Bay and high schools on Montréal Island are examples of this.

In ecological studies, the role of a neighbourhood within a city is considered as a part of a functional systems approach, and thus the impact of the neighbourhood's location becomes very important. The kernel density distribution maps of crime in all Canadian cities show that high-crime neighbourhoods are located near neighbourhoods with similar crime levels. The opposite is also true. However, this spatial correlation of crime should not be viewed only in terms of its negative consequences. It could also have advantages: a reduction in crime in one neighbourhood could have a ripple effect on nearby neighbourhoods. Crime prevention strategies applied to one neighbourhood could benefit adjacent ones.

Opportunities for criminal behaviour increase when neighbourhood land use patterns are conducive to crime (Hayslett-McCall 2002). Land uses that have been associated with crime include mixed patterns of residential, commercial, industrial and vacant lands within neighbourhoods, as well as the presence of particular establishments, such as shopping malls and bars. Land use patterns can impact crime by inhibiting the surveillance or social control capacity of residents in a neighbourhood or by being a focal point for particular types of activities (e.g., consuming alcohol at a bar, selling or using drugs in abandoned structures) (Hayslett-McCall 2002).

The overall picture

The various studies have thus shown that, taken individually, many of the factors involved are closely related. They include, for example, the proportion of the neighbourhood's residents in a low income household, government transfers, and the proportions of tenants, lone-parent families and recent immigrants in a neighbourhood. However, when all characteristics are considered at the same time, a limited number of factors are found to be linked to the differences in the crime rates among neighbourhoods (Table 2). The set of explanatory factors varies in a specific way according to the city and the type of crime, either violent or property. The three key dimensions (demographic, socio-economic and functional) are included in the various explanatory models.

When the effect of the links among the various demographic, socio-economic and functional characteristics was accounted for in the multivariate models, some characteristics associated with high crime rates at the neighbourhood level were rejected by the models (Table 2). This was the case with the proportions of Aboriginal people, immigrants and visible minorities, which the multivariate models indicated

were not linked to higher neighbourhood crime rates. The "Aboriginal people," "immigrants" and "visible minorities" variables were therefore not retained as risk factors associated with higher neighbourhood crime when the socio-economic conditions in which these groups live were taken into account. When socio-economic conditions were held constant, it was found that the ethnocultural composition of Canadian cities was not associated with higher crime in the neighbourhoods of these cities. The Aboriginal issue is explored in greater detail in the "Thematic issues" section.

Access to socio-economic resources (expressed by the low-income cutoff, median income or level of education) and land use characteristics (essentially commercial use) were found to be the risk factors most closely associated with differences in crime rates among neighbourhoods in various Canadian cities.

Table 2

Characteristics associated with neighbourhood crime rates, selected cites, 2001

	Edmonton		Halifax		Montréal		Regina		Thunder Bay		Winnipeg		Saskatoon	
Violent	Property	Violent	Property	Violent	Property	Violent	Property	Violent	Property	Violent	Property	Violent	Property	
Demographic characteristics														
Male-female ratio	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Proportion of people younger than 25	...	–	...	...	...	...	...	...	...	...	...	...	...	...
Proportion of young men aged 15 to 24	...	...	...	...	...	...	+	+	...	...	+	...	...	...
Proportion of single people	...	...	...	...	+	+	...	...	+	+	...	...	...	...
Proportion of lone-parent families	+	+	+	+	...	...	...	...	...	...	...	...	...	...
Proportion of people living alone	...	...	+	...	...	...	...	...	...	...	...	...	...	...
Proportion of people having moved in the previous year	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Proportion of Aboriginal people	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Proportion of visible minorities	...	...	...	...	...	–	...	...	...	...	...	...	...	...
Proportion of immigrants	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Residential mobility[1]	...	...	...	...	...	...	...	...	...	...	...	...	+	+
Population of young people[2]	...	...	...	...	...	...	...	...	...	...	...	...	+	+
Ethnocultural diversity[3]	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Socio-economic characteristics														
Unemployment rate	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Proportion of the population aged 20 years and older without a high school diploma	+	+	...	...	...	...	...	...	...	...	...	...	...	...
Proportion of the population aged 20 years and older with a university diploma	...	...	...	...	–	...	–	–	...	...	...	...	...	...
Occupation	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Median household income	...	...	...	+	...	...	–	...	...	...	...	...	...	...
Proportion of total income represented by government transfers	...	...	...	...	...	...	...	...	+	+	...	...	...	...
Proportion of population in low-income households	+	+	...	...	+	+	...	+	+	...	...	...	...	...
Proportion of households spending more than 30% on shelter	...	...	...	+	...	...	...	...	...	...	...	...	...	...
Socio-economic disadvantage[4]	...	...	...	...	...	...	...	...	...	...	+	+	+	+
Dwelling and land use characteristics														
Bar density	...	...	...	...	...	+	...	...	...	...	...	...	...	...
Proportion of dwellings in need of major repairs	...	...	+	...	...	...	...	...	...	...	+	+	...	...
Proportion of dwellings built before 1961	...	...	...	...	...	...	...	+	...	+	...	...	...	...
Proportion of owner-occupied dwellings	...	...	...	...	...	...	+	...	...	...	...	...	...	...
Multiple-family residential zoning[5]	...	...	...	...	+	...	...	...	...	...	+	...	...	...
Commercial zoning[6]	...	...	...	...	+	...	...	...	...	...	...	...	...	...
Single-family residential zoning[7]	+	+	...	+	+	+	...	+	+	+	+	+	+	+
Aging dwellings[8]	...	...	...	...	...	...	...	...	...	...	...	...	+	+

... not applicable

\+ Characteristic positively associated with neighbourhood crime, net of the other characteristics ($p \leq 0.05$).

– Characteristic negatively associated with neighbourhood crime, net of the other characteristics ($p \leq 0.05$).

1. Factor score used only for Saskatoon. The variables that have the greatest input are related to residential mobility, type of dwelling occupation (owned or rented), low income and size of dwelling.
2. Factor score used only for Saskatoon. The variables that have the greatest input are the percentages of people younger than 15 and 65 years and older.
3. Factor score used only for Saskatoon. The variables that have the greatest input are the percentages of recent immigrants (10 years) and visible minorities.
4. In the case of Winnipeg, this is represented by a index composed of the unemployment rate, the median household income, and the percentages of the population without a high school diploma, with a university diploma and living in a low income household. For Saskatoon, this is a factor score reflecting mostly variables related to education and the portion of income represented by government transfers.
5. In Edmonton, this represents the percentage of dwelling units that are in an apartment building. In the other cities, it is the percentage of the area that is identified as multiple-family residential zoning.
6. In Edmonton, this is the percentage of dwellings units that are single-family detached homes. In the other cities, it is the percentage of the area that is identified as single-family residential zoning.
7. In the case of Edmonton, this is the number of people working in retail trade. In Saskatoon, it is a factor score reflecting mostly the density of retail trade and restaurant workers. In the other cities, it is the percentage of the area identified as commercial zoning.
8. Factor score used only for Saskatoon. The variables that have the greatest input are the percentages of dwellings in need of major repairs and dwellings built before 1961.

Sources: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001 and Census 2001.

Thematic issues

To complement the crime diagnostics, a number of additional issues were addressed in exploratory analyses. In some cases, these analyses highlighted the importance of using a variety of approaches to prevent crime, while in others cases, they illustrated the limitations of the available data.

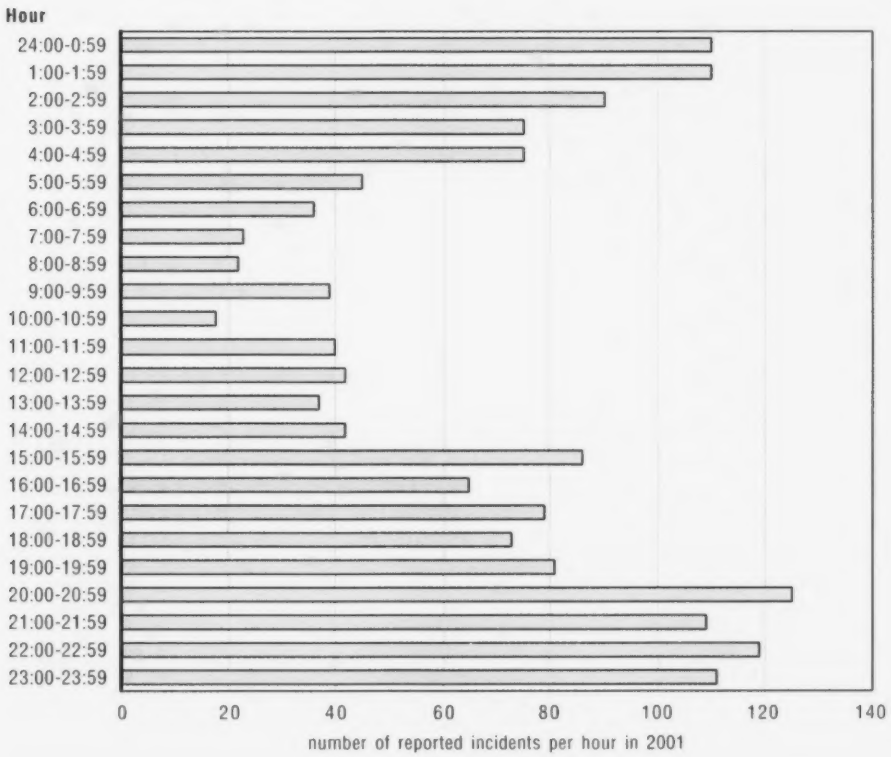
Spatial variations by time of crime: robbery in Winnipeg

While criminal incidents can take place at any time of day in a city, research has shown that the different types of crime do tend to occur at specific times (Assunção, Beato and Silva 2002). The Winnipeg analysis supported this finding in the Canadian context.

Chart 2 shows the distribution, by time of day, of all robbery offences reported in Winnipeg in 2001. The data indicate that fewer robberies took place in the morning and more occurred in the evening before midnight.

Chart 2

Robbery incidents[1] by time of day, Winnipeg, 2001



1. Includes 1,652 reported robbery incidents for which the time of the incident was known.

Source: Statistics Canada, Canadian Centre for Justics Statistics, Incident-Based Uniform Crime Reporting Survey, 2001.

Maps 1 to 3 show the distribution of robbery hot spots at three times of the day, that is, morning (between 7 a.m. and 9 a.m.), evening (8 p.m. to 10 p.m.) and night (1 a.m. to 3 a.m.). In 2001, 4% of all robberies reported occurred between 7 a.m. and 9 a.m., 14% between 8 p.m. and 10 p.m. and 12% between 1 a.m. and 3 a.m.

Spatial distribution varied depending on the time of day, both in terms of the number of criminal offences and the areas where crime density was highest (hot spots), indicated by the darkest red.

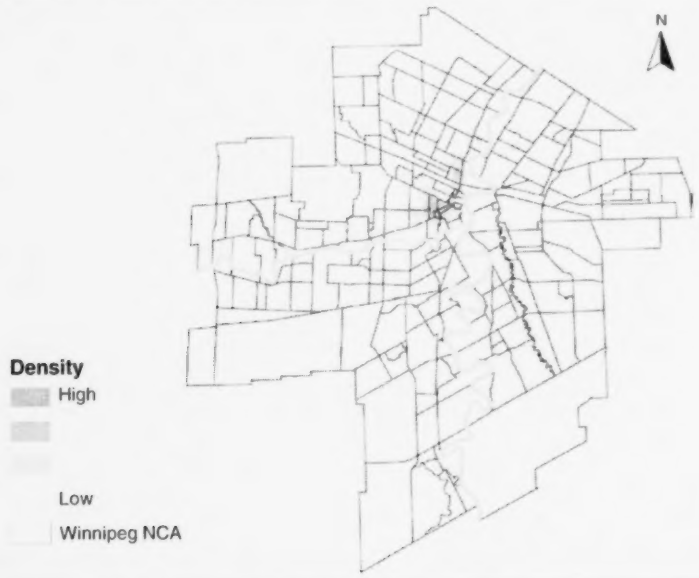
Map 1

Kernel density distribution of morning robbery incidents, 7:00-9:00 AM, Winnipeg, 2001

Based on 52 robbery incidents occurring from 7:00-9:00 AM in 2001.
Note: Neighbourhood characterization area (NCA).
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-Based Uniform Crime Reporting Survey, 2001.

Map 2

Kernel density distribution of evening robbery incidents, 8:00-10:00 PM, Winnipeg, 2001



Based on 254 robbery incidents occurring from 8:00-10:00 PM in 2001.
Note: Neighbourhood characterization area (NCA).
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-Based Uniform Crime Reporting Survey, 2001.

Map 3

Kernel density distribution of night time robbery incidents, 1:00-3:00 AM, Winnipeg, 2001

Based on 220 robbery incidents occurring from 1:00-3:00 AM in 2001.
Note: Neighbourhood characterization area (NCA).
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-Based Uniform Crime Reporting Survey, 2001.

Travel-to-offence patterns of persons charged: analysis of distances travelled in Montréal

According to the opportunity theory of criminal behaviour, the distribution of crime is determined by the convergence of three elements. The opportunity for crime exists when an offender, a target and the absence of a guardian converge in time and space (Felson and Poulsen 2003).

Using data provided by the Service de police de la Ville de Montréal on the location of criminal incidents and the place of residence of persons charged, it was possible to calculate the distance travelled by persons charged.

Overall, persons charged in violent incidents travelled less (0.9 km) than those charged in property incidents (4 km) (Table 3). Other research papers have also shown that persons accused of violent offences travel shorter distances than those accused of property crimes (LeBeau 1987; Turner 1969).

Table 3

Median distance travelled by accused persons, by type of offence, Montréal, 2001

	Road network	Euclidian distance	Total trips
	median distance in kilometres		number
Violent offences	**0.89**	**0.68**	**10,009**
Assaults	0.35	0.26	**6,913**
Sexual assaults	1.29	1.07	**201**
Robbery	3.11	2.52	**958**
Utter threats to person	1.41	1.08	**1,347**
Property offences	**4.16**	**3.38**	**7,744**
Break and enter	3.3	2.65	**1,079**
Theft over and under $5,000	4.38	3.61	**4,550**
Shoplifting	4.1	3.46	**2,897**
Car theft	6.53	5.67	**565**
Total of offences	**2.55**	**2.03**	**21,382**

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

The median distance travelled also varied according to the closeness of the relationship between the person charged and the victim. Those who knew their victim travelled little, while those who did not covered the greatest distances and converged toward the city centre (Table 4).

Table 4

Median distance travelled by persons charged, by relationship with the victim

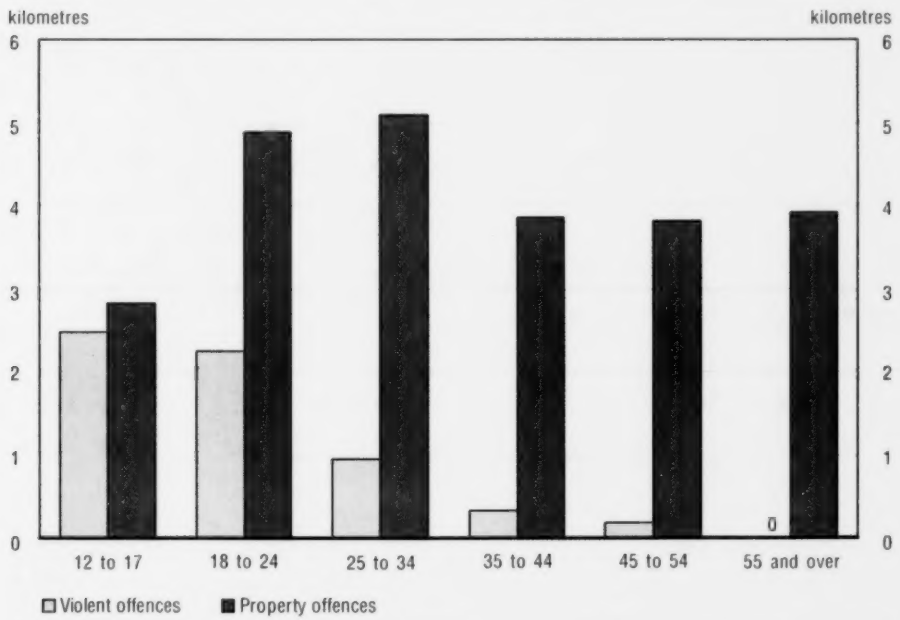
Relationship of victim to person charged	Road network	Euclidean distance	**Total trips for violent incidents**
	median distance in kilometres		**number**
Spouse	0.0	0.0	**3,808**
Ex-spouse	2.1	1.6	**1,290**
Other family member	0.0	0.0	**673**
Acquaintance	1.3	1.0	**3,018**
Stranger	3.0	2.4	**2,820**

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-Based Uniform Crime Reporting Survey, geocoded database, 2001.

This study also found that distances travelled varied according to the age of the persons charged (Chart 3). The youngest travelled the most in violent incidents and the least in incidents involving property. Many foreign studies have produced similar results (Groff and McEwen 2005; Wiles and Costello 2000; Chapin and Brail 1969; Harries 1999). In the case of violent offences, the distance travelled was greatest among adolescents (those between 12 and 17 years of age) and diminished with increasing age.

Chart 3

Median distance[1] travelled by persons charged, by age, Montréal, 2001



0 true zero or a value rounded to 0

1. Distances measured using the road network.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-Based Uniform Crime Reporting Survey, geocoded database, 2001.

This variation is due to the fact that young persons aged 12 to 17 were more likely to target acquaintances (51% of their victims) and strangers (40%) than persons with whom they had any other type of relationship. Starting at age 25, persons charged were consistently more likely to target their spouse (between 26% and 29%), followed by acquaintances (between 24% and 34%) and ex-spouses (between 12% and 16%). Charged persons aged 18 to 24 were the most likely to target strangers (43%). In comparison, the distance travelled to commit property offences was shortest for male and female youth, and peaked between 18 and 34 years of age, after which it stabilized. This pattern may be related to access to various modes of transportation.

Descriptive analyses of the median distance travelled by persons charged led to the finding that distances travelled vary by type of offence, age of the persons charged and their relationship with the victim (Savoie 2006). Results from the Montréal study support British research findings indicating that most offender movements are relatively short, and that travel associated with crime is driven by opportunities presenting themselves during daily activities and routine travel rather than plans to offend (Felson and Clark 1998; Wiles and Costello 2000). Charged persons and their targets vary according to the initial reason for travelling—or not travelling in the case of spousal violence. In this regard, trips initiated for work, school or recreation offer specific opportunities for crime (Felson and Clark 1998). The longest median travel distances, which were recorded for auto theft incidents, may be related to a more organized criminal effort.

Spatial distribution of youth crime: Montréal as an example

The characteristics of distances travelled by charged youth aged 12 to 17 were different from those of adults, as was the spatial distribution of crimes involving at least one youth. Indeed, when youth crime alone was considered, it was found to be distributed in many locations spread across the entire island (Map 4).

Map 4

Spatial distribution of youth crime on the Island of Montréal, 2001

Counts based on 4,369 incidents.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Uniform Crime Reporting Survey, UCR2.2.

Violent crime among youth aged 12 to 17 occurred in a large number of small kernels scattered across the entire island. Several of these kernels corresponded to the location of a secondary school or, in some cases, other public institutions, such as youth centres. In 2001, 27% of violent youth crimes occurred in a school.

Shoplifting was the most frequent crime committed by youth aged 12 to 17, with the density kernels of property crime corresponding to the major shopping malls. The city centre, the Carrefour Angrignon and the Fairview Pointe-Claire shopping mall had the highest property crime densities.

The results of the multivariate analysis indicated that the characteristics of Montréal neighbourhoods had a minor impact on youth crime rates. The presence of a secondary school, commercial zoning and education were three common factors that has a slight influence on the variation of both violent and property police-reported youth crime.

Since school is where most young people spend a good part of their day, they commit many of their crimes nearby. In addition, as Tremblay and Ouimet (2001) have pointed out, the risk of assault or theft increases in places with a high density of urban movement and interaction; two such places are schools and shopping centres. These locations, particularly retail stores, also present crime opportunities for youths, whose property offences are mostly shoplifting and mischief. These findings are consistent with observations by LaGrange (1999), who noted that the presence of a secondary school or a shopping centre was a key factor having an impact on the number of mischief offences. LaGrange pointed out that such places attract a large number of non-residents to a neighbourhood, which would reduce the effectiveness of community surveillance.

Several socio-economic factors, such as the proportions of people living in low-income households, of dwellings requiring major repairs, of members of visible minorities and of people without a secondary school diploma were moderately associated with crime, while the proportion of recent immigrants had the opposite effect. The property crime rate was also slightly increased by residential mobility but decreased by the male-female ratio and the proportion of people with a university degree.

These findings are partly consistent with the hypothesis put forward by Sampson and Raudenbush (1999) and the observations concerning Montréal made by Savoie et al. (2006) that crime varies with social capital and collective efficacy. They are also in keeping with the findings of Jacob (2006), who noted that certain neighbourhood characteristics had little influence on youth crime, but that level of education, occupation and residential instability were major factors.

Although these results reflect those of other studies of youth crime (Jacob 2006; LaGrange 1999), they nevertheless show that neighbourhood characteristics alone are not sufficient to understand youth crime, and that a better approach would be one that integrates family- and individual-level data. Some recent studies (Dupéré et al. 2007; Hay et al. 2006; Simons et al. 2005) suggest that for young people, certain neighbourhood characteristics have an influence primarily through their interaction with family- or individual-level factors. In a survey of self-reported youth delinquency in Toronto, Savoie (2007) noted that some individual and family characteristics were significant risk factors for delinquency among young people. Collecting data on victimization and self-reported delinquency at the neighbourhood level might be particularly useful for the analysis of youth crime.

Exploration of the relationship between neighbourhood crime rates and the Aboriginal population: Regina, Saskatoon and Winnipeg

Numerous studies have shown that the Aboriginal population in Canada is over-represented among victims and offenders (La Prairie 2002; Brzozowski, et al. 2006; Richards 2001). While it should be understood that the spatial analyses discussed in this report cannot make direct connections between Aboriginal residents of neighbourhoods and Aboriginal offenders or victims, the results do suggest that is important to understand the urban context in which Aboriginal people live. In 2001, Regina, Saskatoon and Winnipeg reported the highest proportions in Canada of Aboriginal people in census metropolitan areas, respectively 8.3%, 9.1% and 8.4% of the population.

Wallace et al. (2006) pointed out the need to identify the characteristics associated with neighbourhoods where a high proportion of Aboriginal people lived. In Regina, the neighbourhoods with higher proportions of Aboriginal people also tended to have a high unemployment rate, housing in need of repair, and high proportions of low-income households, populations receiving government transfers, low education rates, multi-family dwellings, tenants and people who had recently moved. It was shown that many of these factors were related to higher neighbourhood crime rates.

In the case of Saskatoon, the research showed that the city's neighbourhoods differed according to several characteristics, notably socio-economic disadvantage, aging dwellings, residential mobility, the age of the population and commercial activity, but not by Aboriginal status (Charron 2008). In Saskatoon, Aboriginal people tended to live in neighbourhoods characterized by aging dwellings, socio-economic disadvantage and residential mobility—all factors strongly associated with crime (Charron 2008). No direct relationship was found between variations in crime measured at the neighbourhood level and the Aboriginal population.

Winnipeg offered the first opportunity to examine the nature and extent of the over-representation of Aboriginal people among police-reported offenders at the neighbourhood level. Based on the more detailed analysis by Fitzgerald and Carrington (forthcoming in 2008 in the *Canadian Journal of Criminology*), Aboriginal people are almost seven times more likely than non-Aboriginal people to be identified by police as offenders. In Winnipeg, as in Regina and Saskatoon, more Aboriginal people live in high-crime neighbourhoods. The authors determined that, together, socio-economic disadvantage and residential mobility explained 61% of the differences in the percentages of the Aboriginal population among Winnipeg neighbourhoods. They also determined that the higher probability of Aboriginal people being identified as offenders in police-reported data was due to the location of the offence and, more specifically, to the living conditions in the neighbourhoods in which Aboriginal people were presumed to have committed crimes. This result confirms La Prairie's (2002) hypothesis that the structural conditions of cities contribute to the over-representation of Aboriginal people as offenders in the Criminal Justice System.

Fitzgerald and Carrington (forthcoming in 2008 in the *Canadian Journal of Criminology*) concluded that a significant portion of the high police-reported crime rate among Aboriginal people can be explained by the structural characteristics of the neighbourhoods in which they tend to live.

Variations in crime and neighbourhood characteristics over time: exploration of possibilities in Regina

An initial exploratory analysis to measure variations in crime and neighbourhood characteristics over time was included in the Regina research. While it was found that crime rates are statistically associated with certain neighbourhood characteristics, the changes in these same characteristics occur over several years. For this reason, trends in crime at the neighbourhood level can only be noticeable at a certain level (volume) and after a period of time.

The availability of data represented a major limitation in this initial exploration of change over time. An examination of changes over time in neighbourhood crime must account for changes in the populations and characteristics of neighbourhoods. This initial research was based on geocoded crime data for 1999 and 2003, and since these years were not census years, census data on populations and neighbourhood characteristics were not available. However, Statistics Canada's Small Area and Administrative Data Division was able to provide neighbourhood population figures along with data on income categories and median income, which it drew from the annual tax data record provided by the Canada Revenue Agency. Given that in Regina, household income was found to be a key predictor of the variation in violent and property crime rates in 2001, the availability of income data is an important characteristic to explore over time.

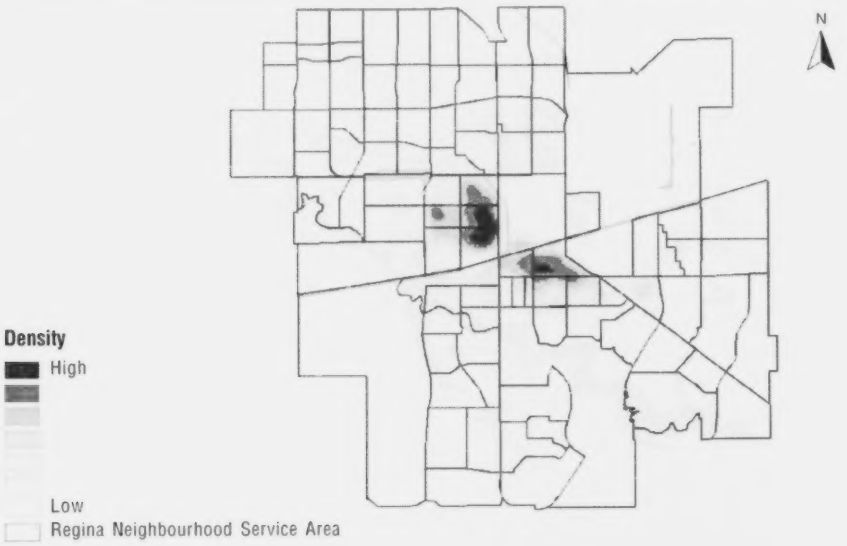
One change over time that is likely to influence crime levels in neighbourhoods is the variation in the number of residents. The total population for the entire territory of the City of Regina fell 1% between 1999 and 2003. Demographic changes varied from neighbourhood to neighbourhood, ranging from a decline of 10% in Glen Elm to an increase of 18% in McNab. In the case of violent crime rates, it was found that a majority of neighbourhoods with violent crime rates that were higher than the overall rate for Regina in 1999 saw a decrease in their populations between 1999 and 2003 (Map 5 and 6). In their study of violent crime in Chicago between 1970 and 1990, Morenoff and Sampson (1997) observed that neighbourhoods with high homicide rates tended to experience a drop in population as residents sought to move to safer neighbourhoods.

While the multivariate analysis of the crime rates in Regina and of the neighbourhood characteristics for 2001 showed that income was a determining factor in the variations of the extent of crime among neighbourhoods, a second type of change that must be taken into account is access to economic resources. Although these same income indicators (median household income and proportion of low-income private households) were not available for 1999 and 2001, some data on personal income were.

To examine the relationship between income and neighbourhood crime rates over time, neighbourhoods were divided into two groups for each year. The first group consisted of the 25% of neighbourhoods with the highest proportion of persons reporting an income of $50,000 or more, referred to as "high-income neighbourhoods." The second group consisted of the other 75% of neighbourhoods, referred to as "lower-income neighbourhoods." Without taking other factors into account, significant differences were found between the high-income neighbourhoods and the lower-income neighbourhoods.

Map 5

Kernel density distribution of violent crime incidents, Regina, 1999

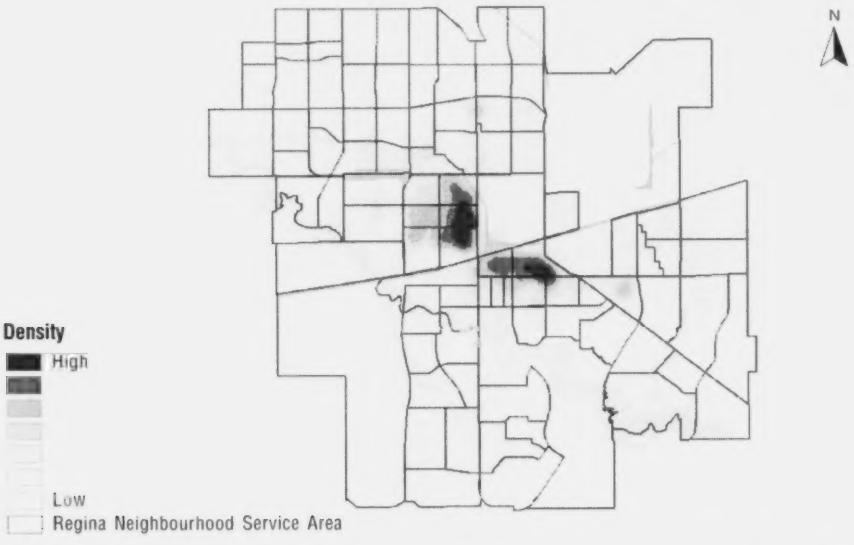


Based on 3,070 violent crime incidents.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, 1999.

Map 6

Kernel density distribution of violent crime incidents, Regina, 2003



Based on 3,091 violent crime incidents.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, 2003.

In general, high-income neighbourhoods had significantly lower property crime rates than lower-income neighbourhoods. This remained true over time. Differences between violent crime rates in high- and lower-income neighbourhoods did not remain significant over time.

The analytical work by Wallace et al. (2006) in Regina highlights the importance of having access to longer time series of criminal incidents in neighbourhoods and to multiple data sources. Furthermore, an examination of the distribution of the frequency of neighbourhood crime (hot spots) for 2001 and 2004 in all other cities studied indicated that the distribution of both property and violent crimes remained relatively stable during that period. Based on the results of the multivariate analysis conducted as part of this analytical series, it would seem essential to explore the change in socio-economic and functional characteristics of neighbourhoods over time in order to understand the spatial distribution of crime.

Conclusion

On one hand, this series on the spatial analysis of crime highlights the fact that the spatial organization of crime must be viewed as the result, at a given moment in time, of the slow and complex process of urban development. Moreover, it underlines the importance of the social networks (social capital) developed and maintained by neighbourhood residents. Neighbourhoods evolve with the people living in them. Residents move or stay, communities move, reconstitute and change, and as buildings age they are renovated or left in need of repair. The neighbourhood is a combination of material and symbolic conditions that structure the day-to-day lives and the identity of its population (Debarbieux 2003). These conditions, which are uniquely local, can play a key role in the occurrence of crime. It is in this evolving and complex context, situated in time and space, that crime, its spatial organization and its association with neighbourhoods must be understood.

These findings indicate that strategies to fight crime must be developed in light of specific local demographic, socio-economic and functional dimensions. By adapting crime prevention strategies to the specific needs of each city, based on its history and the resources available at the neighbourhood and community levels, these strategies will be more likely to produce the desired results.

It is important for spatial analysis research of crime to include many data sources in order to effectively cover the many aspects and dynamics of the issue. The studies in this series relied on statistical data from police forces, which include only crimes reported to them that have been substantiated by a police investigation. Many factors can influence the police-reported crime rate, including the willingness of the public to report crimes to the police and changes in legislation, policies or enforcement practices.

In coming years, it would be useful to examine, at the neighbourhood level, the information collected in victim and offender surveys, which in turn would provide a picture that could lead to the development of new crime prevention strategies. Population surveys would make it possible to define more clearly the role played by community participation and social inclusion or exclusion in crime prevention. Sampson et al. (2002) highlighted the theoretical and technical problems associated with measuring several neighbourhood characteristics related to crime. In particular, they pointed out the usefulness of measuring social networks, standards and collective

efficacy, institutional resources, community engagement, and even the travel patterns of residents and users in neighbourhoods.

Understanding factors related to change over time is also important for developing crime prevention and reduction strategies and for evaluating existing programs. The 2006 Census data will provide new demographic and socio-economic data at the neighbourhood level. These will make it possible to explore change over time and consequently, to see for the first time the combined evolution of all factors associated with variations in crime at the neighbourhood level using geographic information technologies.

In future studies, these data will offer opportunities to focus on change over time and hence on the causal nature of the factors involved. Some questions merit special attention: What factors are associated with the shift in poverty between neighbourhoods? What is the impact of the polarization of poverty and its persistence at the neighbourhood level? Is this shift in poverty also accompanied by changes in the composition and levels of crime? Which neighbourhoods are at greatest risk?

In addition, despite the related operational difficulties, the integration of existing social and crime reduction programs in future analyses could provide a better understanding of the effectiveness of current programs in preventing crime. Future research is required to define and evaluate strategies such as before- and after-school programs and neighbourhood watch programs.

This information would help answer such questions as: Does criminal activity simply shift to other neighbourhoods? What types of social or crime prevention programs are most effective? Which neighbourhoods have low crime rates despite presenting other risk factors?

It will also be necessary to conduct more research to address the capacity of communities to develop human and social capital and to transform this into collective efficacy. As the body of research grows in the area of crime mapping within the Canadian context, it would be useful to examine the mechanisms at play in neighbourhoods presenting numerous risk factors but not high crime rates. This would contribute to a better understanding of the dynamics of collective efficacy.

Although some American research has found a significant statistical relationship between certain neighbourhood characteristics, and ethnicity in particular, Canadian studies exhibit several nuances and features that do not support such links. For this reason, there are important constraints on the transposition as a whole of the findings of American research to the Canadian context. This last observation highlights the need to examine data on the structures and processes within Canadian communities in order to develop crime prevention strategies that will have the best chance of success.

Methodology

This section explains some of the methodological considerations of the spatial analysis of crime data. It is not intended to provide a detailed description of the methodology used in each of the series' studies, but rather to provide an overview of the analysis and the data sources used.

Data sources

Neighbourhood characteristics data

Data on all demographic and socio-economic characteristics and on some functional characteristics were drawn from the 2001 Census. The detailed socio-economic data used in this analytical series were derived from the long form of the Census, which is completed by a 20% sample of households. These data exclude the institutional population, that is, individuals living in hospitals, nursing homes, prisons and other institutions. To ensure data confidentiality and reliability, Statistics Canada requires that when using income data, the population of any Canadian geographic area being considered must total at least 250 people living in at least 40 private households. A detailed description of all characteristics (variables) and the coverage is provided in each of the studies.

The cities of Winnipeg, Regina, Montréal, Halifax and Thunder Bay provided data on zoning or land use, based on availability. Some of these data were combined in larger categories and then presented at the neighbourhood level to obtain proportions of broad land use categories that were relatively comparable from city to city.

Crime data

The highly confidential nature of geocoded crime data could limit sharing and dissemination. For many years, Canadian police forces have sent the Canadian Centre for Justice Statistics (CCJS) information on criminal incidents, accused and victims as part of the Uniform Crime Reporting (UCR) Survey for statistical purposes. It was in this well-established relationship of trust that various police forces provided to the CCJS the addresses (or geographic coordinates as the case may be) of selected incidents. The CCJS would again like to thank those persons within the participating police forces who submitted the data files needed for the spatial analyses.

This analytical series focused on a selected set of criminal offences, including most *Criminal Code* offences and all offences under the *Controlled Drug and Substances Act*, but excluded offences under other federal statutes, provincial statutes and municipal by-laws. Also excluded were *Criminal Code* offences for which there was either no expected pattern of spatial distribution or a lack of information

about the actual location of the offence. For example, administrative offences such as bail violations, failure to appear and breaches of probation are typically reported at court locations; threatening or harassing phone calls are often reported at the receiving end of the call; and impaired driving offences are more likely to be related to the location of apprehension (for example, apprehension resulting from roadside stop programs).

For this spatial analysis series, police forces sent the CCJS the addresses or geographic coordinates (X and Y) of incidents selected, reported and entered in the Incident-Based UCR database. This information was resolved by the CCJS into a set of geographical coordinates (X and Y) for each address. These coordinates were rolled up to the mid-point of a block-face in the case of specific addresses, and to intersection points in the case of streets, parks and subway stations. For all of the cities examined, the geocoding exercise was successful for more than 92% of the data selected. Incidents that failed geocoding contained information that was too vague, such as a bus number or the Trans-Canada registration. The low percentage of incidents that failed geocoding did not create a bias in offence trends. In fact, geocoded offences and offences prior to geocoding both accounted for the same proportion of overall crime.

Definition of neighbourhood and its impact

Ecological studies such as those conducted in crime-mapping projects require a sufficiently large number of geographic units, or neighbourhoods, for the data modeling to be effective and reliable. The boundaries selected for neighbourhoods can also impact our understanding of the distribution of their characteristics. Few Canadian studies have looked at the changes associated with the various levels of aggregation used in multivariate analyses.

However, there are three elements to be used in guiding the scientific approach to choosing the aggregation level of ecological studies (Messner and Anselin 2004). The first is the relevance of the scale used with respect to the identified objectives. The objectives of this analytical series were to identify patterns of spatial distribution of crime in cities and to target the needs of neighbourhoods most at risk in order to develop crime prevention strategies. Such strategies would have implications for social development at the federal level, but would be implemented at the local level. Using predefined administrative geographic areas made it possible to add layers of additional information (health, education, economic factors, etc.) for an integrated approach to prevention in neighbourhoods with many risk factors. In cases where the research focuses on structural conditions, using predefined administrative geographic areas is a valid approach.

It must be recognized that the relationship between variables measured at the level of administrative geographic areas in an ecological study does not necessarily represent the relationship that exists at the individual level. Considerable caution must be used when making inferences or generalizations about individuals based on ecological studies. Such inferences are acceptable only in rare situations of homogeneity. In other words, the crime rate measured at the neighbourhood level, and its correlates, do not necessarily correspond to the delinquency rate of the residents in these neighbourhoods.

A second element to consider relates to the instability of the variance in crime rates of small geographic units. When all geographic units do not have the same population, the variance in crime rates is not constant and is inversely related to the size of the population (larger populations produce more accurate estimates) (Messner and Anselin 2004). This instability may impact the interpretation of results. However, this problem is more likely to occur when trying to analyse rare events, such as homicides.

A third consideration is the possible interpretation of spatial autocorrelation. Are we really seeing spatial autocorrelation of crime or is it simply a bias caused by the level of aggregation (Messner and Anselin 2004)? In this analytical series, the kernel density distributions compared with the distribution of crime rates at the neighbourhood level showed similar trends in all areas studied. Thus, finding spatial autocorrelation in the cities examined might be the result of a process of spillage or contamination, or of an external variable that was not included in the analysis.

Population at risk

Normally, crime rates are calculated by examining the distribution of incidents in relation to the residential population of a given area. This method offers good results at the municipal, provincial and national levels but it presents some problems when the spatial units of interest, such as neighbourhoods in the city centre, contain small residential populations and large transitory populations. Rates based on residential population alone will artificially inflate the crime rates in these urban core neighbourhoods, since the total population at risk in these areas has not been taken into account.

Rates based on the combined resident and employee populations (population at risk) more closely approximate the total number of people at risk of experiencing crime, that is, the potential target population. These rates are not only better suited to measuring the distribution of violent crimes, which produce victims, but they can also be a better measure of property crimes since the number of residents and workers offers a more accurate estimate of the number of dwellings and businesses that may be the target of property crimes.

Modeling techniques

In this analytical series, ordinary least squares regression was used to examine the distribution of violent and property crime rates as a function of the set of explanatory factors. The use of this method requires continuous or quantitative outcome variables that have a normal distribution. Since several of the variables studied in this analysis do not have normal distributions, it was necessary to standardize the crime variables. Most of the variables, or neighbourhood characteristics, were also adjusted to present a normal distribution. All variables and the related standardization techniques are described in the methodology section of each of the studies.

The regression models were developed using the stepwise regression method. This method consists of a series of multiple regressions in which the variable that accounts for the maximum remaining variance is added at each stage. Any superfluous variables are eliminated at each stage.

The standardized regression coefficients provide a means of assessing the relative importance of the different independent variables in the multiple regression models. The coefficients indicate the expected change, in standard deviation units, of the dependent variable per one standard deviation unit increase in the independent variable, after controlling for the other variables. The maximum possible values are +1 and -1, with coefficient values closer to 0 indicating a weaker contribution to the explanation of the dependent variable.

Many of the neighbourhood characteristics are highly correlated with each other, which means that they convey essentially the same information (correlation matrices are available in the appended documents). This multicollinearity stems from the strong association among many structural factors that are individually linked to crime (Land et al. 1990). To take into account this multicollinearity, which may distort the results of the models, this series made use of variance inflation factors (VIF) to measure the multicollinearity between all of the independent variables in the regression models. A VIF over 10 is indicative of potential multicollinearity problems in a regression model (Montgomery et al. 2001) and, as a result, any variable with a VIF of 5 or above was removed from the final models.

Another aspect that must be taken into account in modeling georeferenced data is spatial autocorrelation.[1] Data measured over a two-dimensional study area, such as geocoded criminal incidents, are often affected by the properties of their location. If adjacent observations are subject to the same location properties, the observations will not be independent of one another. This lack of independence must be accounted for in the data analysis to produce accurate and unbiased results.

When autocorrelation is present in the residuals of a regression model, modeling the relationships between neighbourhoods must take their relative geographic position into account. Use of a spatial autoregressive model is therefore required in these situations.

A definition of what constitutes neighbouring locations is also required. In this analytical series, a contiguity structure that included all common borders or vertices that touch between the boundaries of the neighbourhoods is used to define regions as neighbours of each other. The neighbourhood structure defines which locations have a potential influence on each other, the neighbours, and rules out any potential influence of regions that are not considered to be neighbours. The neighbourhood structure is used to test for spatial autocorrelation and to specify the spatial component in the autoregressive spatial model.

1. A more detailed examination of spatial autocorrelation is provided by Krista Collins in Mathieu Charron. 2008. "Neighbourhood characteristics and the distribution of crime in Saskatoon." *Crime and Justice Research Paper Series*. Statistics Canada Catalogue no. 85-561-XIE No. 12.

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Series list

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Fitzgerald, Robin, Michael Wisener and Josée Savoie. 2004. "Neighbourhood characteristics and the distribution of crime in Winnipeg." *Crime and Justice Research Paper Series.* Statistics Canada Catalogue no. 85-561-XIE, no. 4.

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